Framework for K-12 Science Education Crosscutting Concepts in Science Performances

Building Capacity in Science Instruction through the Framework for K-12 Science Education

A Workshop for Science Educators and Leaders Presented by Utah State Office of Education Dixie State University

and

Partnership for Effective Science Teaching and Learning

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Overview

- Role of Crosscutting Concepts in Science Performances
- NRC Framework for K-12 Science Education
 - Keys to the Vision for Science Education
 - Crosscutting Concepts
- Science Performance
- Focus on One Crosscutting Concept
- Discussion

Common Themes, Unifying Concepts, and Crosscutting Content

- Four Common Themes in the AAAS Benchmarks for Science Literacy (1995) –
 1) systems, 2) scale, 3) change and constancy, and 4) models
- Five Unifying Concepts in the National Science Education Standards (1996)
 - 1) systems, order, and organization, 2) evidence, models, and explanation,
 - 3) change, constancy, and measurement, 4) Evolution and equilibrium,
 - 5) form and function
- Crosscutting Content in the NAEP 2009 Science Framework –
 Crosscutting content are described conceptually and appear throughout the NAEP

Framework. Examples include: Energy Sources and Transfer in Physical Science; Uses, Transformations, and Conservation of Energy in Life Science; and Biogeochemical Cycles in Earth and Space Sciences, the theory of plate tectonics and the evolution of Earth's surface are inextricably linked with environmental pressures (such as geographic barriers), speciation, and the evolution of life. Such examples illustrate opportunities for assessing specific content in greater depth.

What Makes NGSS Different?

- Explicit in the Performance Expectations
- Described in detail in the Framework and NGSS (Appendix G)
- Progression of Concepts across grade levels
- Science Performances include the crosscutting concepts as an integral part of students practices in terms of evidence to support explanations, gather information (observation), and develop arguments

Crosscutting Concepts

- 1. Patterns
- 2. Cause and Effect
- 3. Scale, Proportion, and Quantity
- 4. Structure and Function
- 5. Systems and System Models
- 6. Energy and Matter
- 7. Stability and Change

Structure/Dimensions of the *Framework*

- Science and Engineering Practices
- Crosscutting Concepts
- Disciplinary Core Ideas

"The three dimensions of the Framework, which constitute the major conclusions of this report, are presented in separate chapters. However, in order to facilitate students' learning, the dimensions must be woven together in standards, curricula, instruction, and assessments.

When they explore particular disciplinary ideas from Dimension 3, students will do so by engaging in practices articulated in Dimension 1 and should be helped to make connections to the crosscutting concepts in Dimension 2."

NRC Framework Pages 29 - 30

3-D Model = Science Performance at the Intersection

Science and Engineering Practices

3D Student Performances

- 1. Instruction
- 2. Assessment
- 3. Instructional Materials
 - 4. Professional Development

Crosscutting Concepts

Disciplinary Core Ideas

What are Crosscutting Concepts?

- Crosscutting concepts scaffold across disciplinary boundaries and contribute to sense making and support students in valuing and using science and engineering practices.
- The Framework describes seven crosscutting concepts that support understanding of the natural sciences and engineering.
- The crosscutting concepts, when made explicit for students, contribute to their understanding of a coherent and scientifically-based view of the world.
- Crosscutting concepts have utility for instruction.

Crosscutting Concepts and Instruction

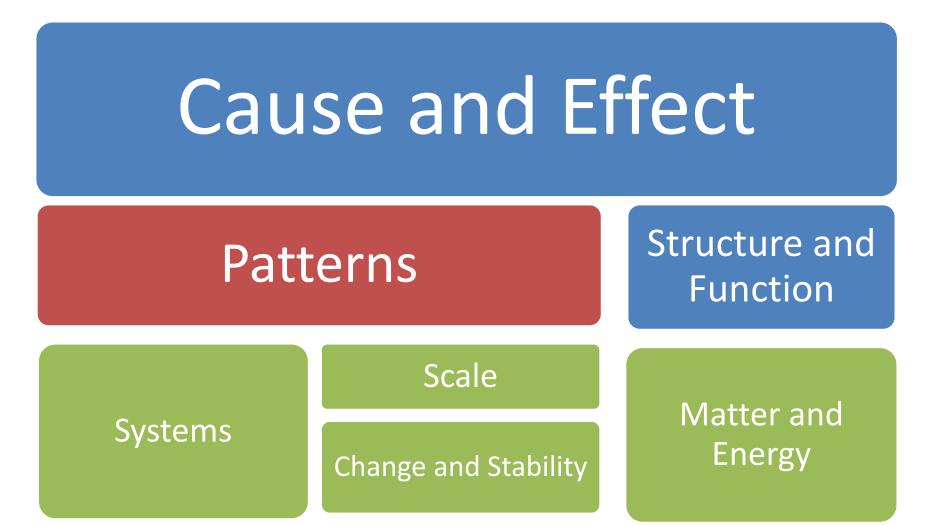
 Although crosscutting concepts are fundamental to an understanding of science and engineering, students have often been expected to build such knowledge without any explicit instructional support. Hence the purpose of highlighting them as Dimension 2 of the Framework is to elevate their role in the development of standards, curricula, instruction, and assessments. Crosscutting concepts should become common and familiar touchstones across the disciplines and grade levels. Explicit reference to the concepts, as well as their emergence in multiple disciplinary contexts, can help students develop a cumulative, coherent, and usable understanding of science and engineering.

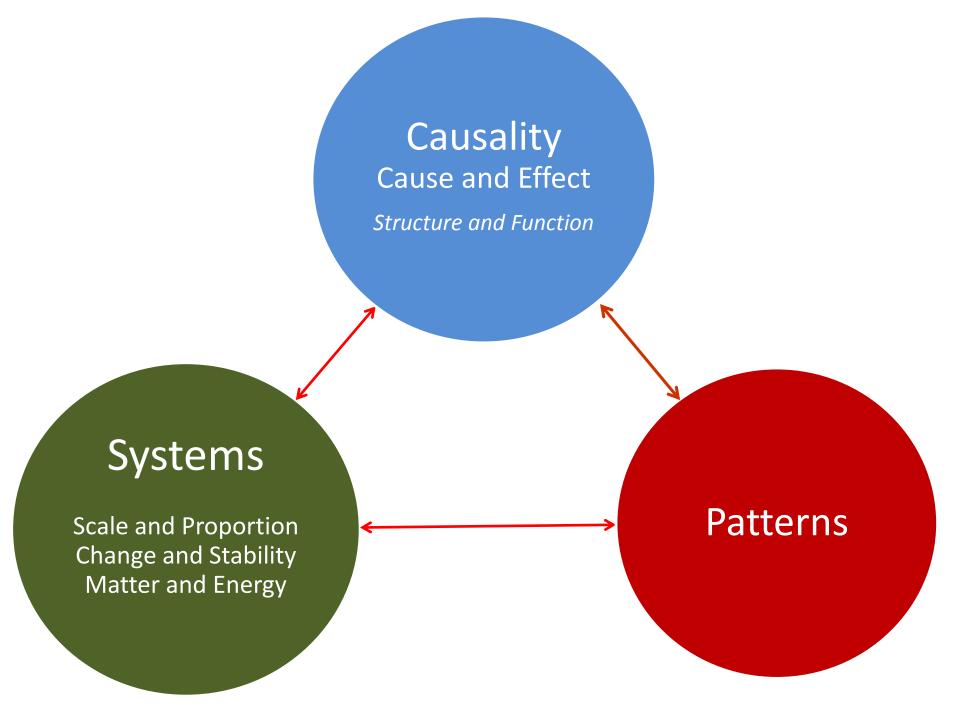
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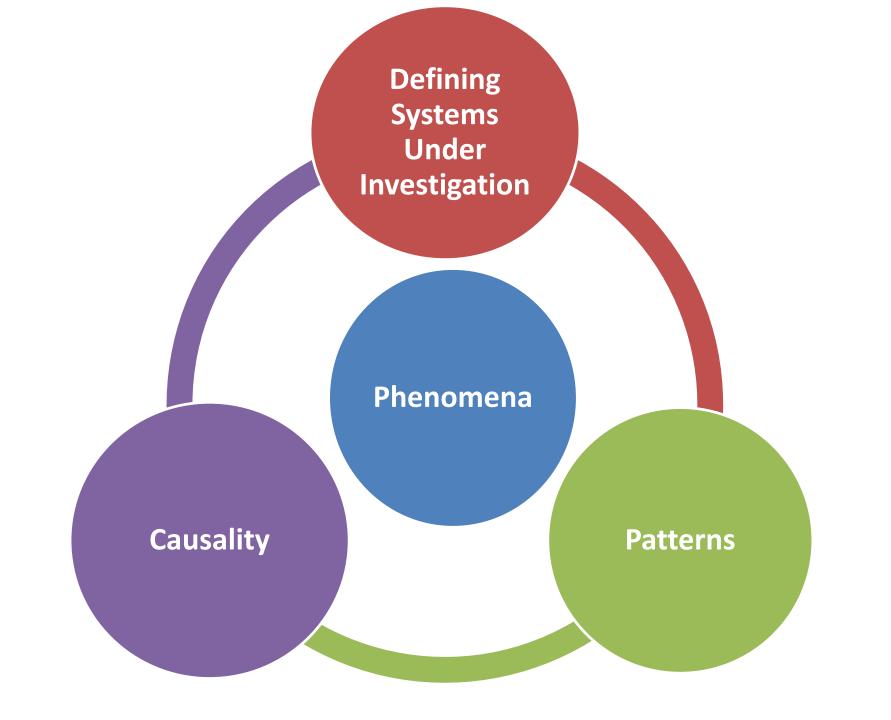
Crosscutting Concepts

The *Framework* has identified seven key Crosscutting Concepts that serve a variety of purposes in science. This is one way to organize them for instruction.





- 1. Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them
- **2. Cause and effect:** Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- **3.** *Scale, proportion, and quantity.* In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a **system's** structure or performance.
- **4. Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that **system**—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
- **5.** Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
- **6. Structure and function**. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
- **7. Stability and change.** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a **system** are critical elements of study.



Performance: Sham-Wow!

Group Performance

Investigate how water moves from one cup to another through a Sham-Wow.

- 1. Explore Place water in one cup, place an empty cup next to it. Connect the water in the first cup to the empty cup with a "Sham-Wow-Lette"
- 2. Formulate questions and investigate explanations for how the water moves from one cup to the other cup.
- Develop evidence to support your explanations.

Individual Performance

4. Write in your journal or on note paper your **explanation** to explain this phenomena. Include **evidence** to support your **explanation** for what **caused** the water to move from one cup to the other. (SSW)

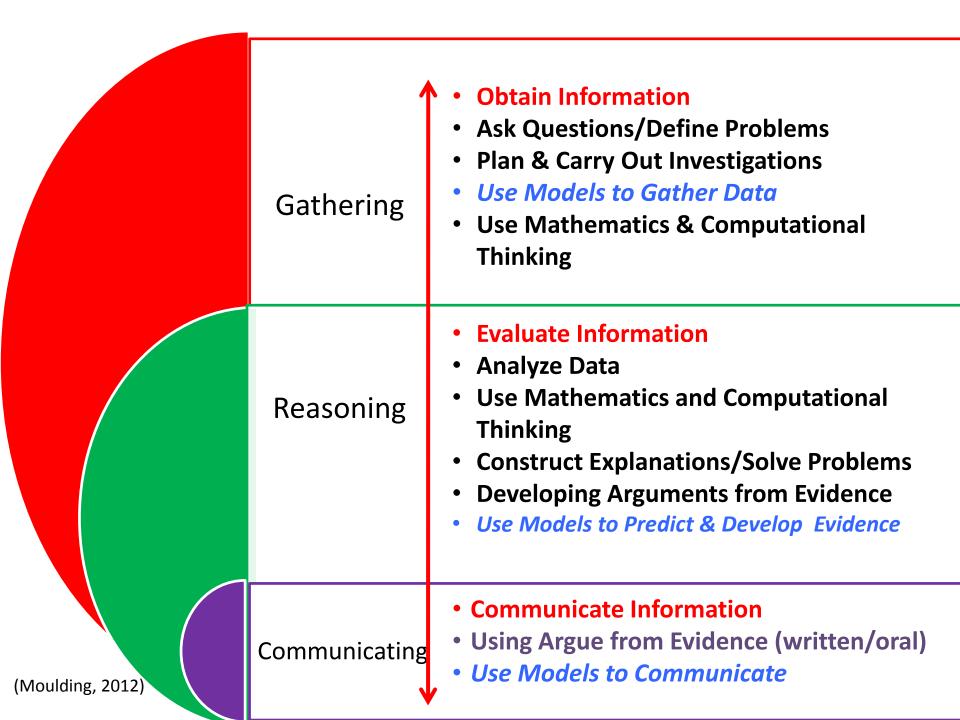
Group Discussion

Science Reflection

5. Write in your journal the **forces** involved in the movement of water from one cup to the other.

Teacher Reflection

6. Reflect on the nature of science instruction that leads students to develop **explanations** based upon **evidence**.



"Change" in the NGSS Performance Expectations

- 4-PS3-3. Ask questions and predict outcomes about the *changes* in energy that occur when objects collide.
- MS-LS2-4. Construct an argument supported by empirical evidence that *changes* to physical or biological components of an ecosystem affect populations.
- HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.

Stability and Change

- Change as the natural result of time
- Rate of change
- Stability
- Stability at one scale of time, size, or distance is change at another scale

Stability

- Stability denotes a condition in which some aspects of a system are unchanging, at least at the scale of observation.
- Stability means that a small disturbance will fade away—that
 is, the system will stay in, or return to, the stable condition.
 Such stability can take different forms, with the simplest being
 a static equilibrium, such as a ladder leaning on a wall.
- By contrast, a system with steady inflows and outflows (i.e., constant conditions) is said to be in dynamic equilibrium.

Stability in Cycles

- A repeating pattern of cyclic change—such as the moon orbiting Earth—can also be seen as a stable situation, even though it is clearly not static.
- Such a system has constant aspects, however, such as the distance from Earth to the moon, the period of its orbit, and the pattern of phases seen over time.

Designed Stability

- Systems are often designed for stable operation
- Feedback loops are used to trigger an action that causes a change back to a desired stable condition:
 - Thermostat control feedback to furnace or AC to control temperature
 - Float on tank control feedback to valve to control water level in tank
- Feedback

Stability, Change, and Time

 A system may be described as stable at one time scale but changing at another scale

(e.g., geologic formations, climate, ecosystems, populations)

 Understanding "Change" as a concept may require understanding deep time.

"An understanding of geologic history and the history of life requires a comprehension of time that initially may for some be disconcerting."

James Hutton proposed the idea of deep time in the 18th century.

One of Hutton's contemporaries, John Playfair, while on a field trip with Hutton to study the unconformity in the rock formations at Siccar Point Scotland stated, "The mind seemed to grow giddy by looking so far into the abyss of time."

Causality and Change

- Changes have causes that can be described.
- Determining the "cause and effect" relationships in systems often requires students to seek the causes of changes.
- The practice of "constructing explanations" for phenomena often focuses on describing the mechanisms of observed changes in a system.

Systems and Change

- Stability and changes are often used in describing or defining a system.
- Stability and change are useful for developing understanding of the scale of systems.
- Useful questions about systems provide insights into the nature of the system:
 - "How is the system changing?"
 - "What is the rate of change of the system?"
 - "What is causing the change in the system?"

Patterns and Change

 Observing changes in systems is an important way students are able to determine patterns

Discussion and Questions



Thank you,

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